Provisional Instruction Manual
for
Crossed Fields Multiplier
Type TA 721

THE SOLARTRON ELECTRONIC GROUP LTD
Thames Ditton, Surrey, England

MP MASTER
MA24436

SOLARTRON

Instruction Manual for the Crossed Fields Multiplier Type TA 721

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CROSSED FIELDS MULTIPLIER.
TYPE T.A.721
SERIAL No.49496
SOLARTRON
LABORATORY INSTRUMENTS LTD.
THAMES DITTON ENGLAND
SET LEVEL
OVERLOAD

SECTION 1

INTRODUCTION

The crossed fields multiplier is one of a range of computer sub-units which are compatible with one another and which may be combined together to form large computer installations. This unit rapidly multiplies together two variables and may be arranged under certain external configurations to divide. It operates on a machine unit of 100 V and has a scale factor of 0.01 so that with 100 V on both inputs the output is also 100 V. The overall accuracy is better than 1.0% of full output. The amplitude and phase error at 1 kc/s is less than 1% and 1° respectively. The internal feedback system uses drift corrected DC amplifiers which provide a high degree of stability.

SECTION 2

DATA SUMMARY

2.1 Description

The crossed fields multiplier is of modular construction comprising a main frame housing the crossed fields multiplier tube and mounting five sub-units which may be withdrawn from the rear of the unit. The main frame also carries the front panel on which are mounted a mains fuse, a signal lamp and an overload neon. In addition to the five sub-units at the rear, there is the mains input, a mains selector panel and an 8-way connector. This multi-way connector brings into the unit ± 300 V DC a signal earth, a supply earth and a mains earth. It also carries an overload line to a central overload indicator at the control position. The panels of the five sub-units carry a number of preset controls, together with the input and output sockets. These preset controls are set up before the equipment leaves the factory and under normal circumstances should require no further adjustment unless the multiplier tube is changed or other servicing is carried out on the equipment. The exception to this is the DC output level control. Instructions for setting this control are given in the Operating Instructions.

2.2 Performance Specification

Inputs. There are two inputs, each by coaxial and 3 mm sockets. One is mounted on the coil amplifier and the other on the X amplifier.

	X Amplifier	Coil Amplifier
Input voltage range	± 100 V	± 100 V
Input impedance	2 MΩ	1 MΩ

Output. The output is taken from the servo amplifier on a coaxial and a 3 mm socket.

Output voltage range ± 100 V.

Output current ± 8 mA maximum.

Static Accuracy ± 1% of full scale.

Dynamic Accuracy — At 1 kc/s
Amplitude error <1%
Phase error <1°

Scale factor 0.01 i.e.

$$\text{output} = \frac{\text{input 1} \times \text{input 2}}{100}$$

Power Requirements: 110 or 220 V ± 20 V A.C. 50/60 c/s 15 VA:
+ 300 V DC 80 mA:
- 300 V DC 60 mA.

2.3 Dimensions

Front panel size 19" x 7".
Depth 18" to the rear of the 8-way connector.
Weight 40 lbs.

SECTION 3

INSTALLATION & OPERATING INSTRUCTIONS

On receipt of the equipment unpack it and check that the valves are all firmly in their sockets. Mount the unit in a Post Office type rack as required. Connect the mains supply to the Mk IV Plessey plug on the rear of the unit and connect the ± 300 V, signal earth and supply earth and supply earth to the red range McMurdo socket on the rear of the equipment. If required, the mains earth and the remote overload line may also be connected. Switch on the equipment and allow 30 minutes warming up time. Connect the two inputs to the signal earth. Adjust the set output DC level control on the 'X' amplifier for zero DC at the output socket. Disconnect the inputs from earth. The equipment is now ready for use.

SECTION 4

PRINCIPLES OF OPERATION

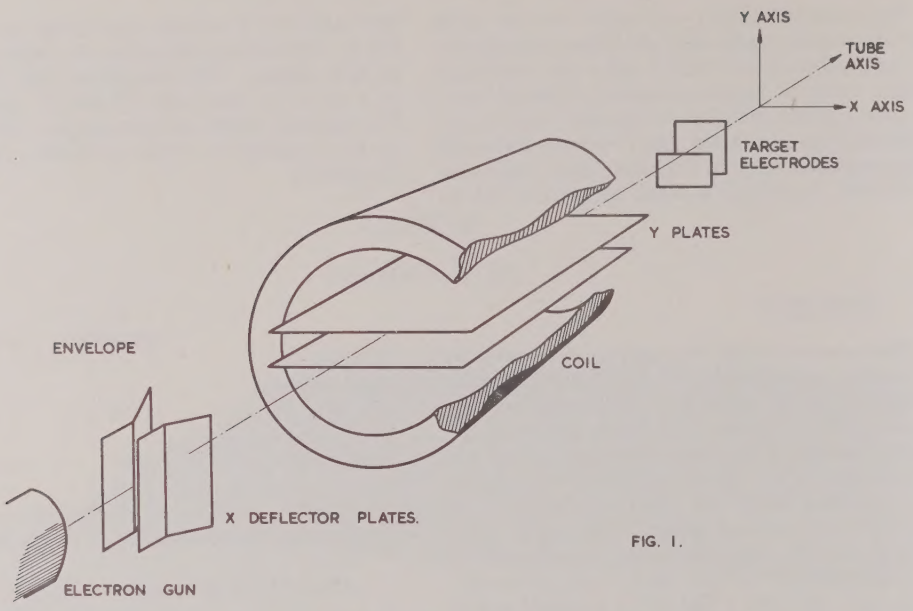

Fig. 1. The Multiplier Tube

4.1 Theory

The basic principle of operation is that the force on an electron moving with a velocity V at right angles to a magnetic field H is balanced by that due to an electric cross field E. E is then proportional to HV. This principle is put into operation in the multiplier tube 490CAX.

4.2 The Multiplier Tube 490CAX

This is a cathode ray tube designed as a multiplier. The electron gun is of conventional form and uses stabilised accelerating potentials so that the axial component of electron velocity through the deflection fields is constant. The screen is replaced by two rectangular target electrodes (see Fig. 1) and when there is no vertical deflection the beam current divides equally between them.

When any vertical deflection occurs, the current balance will be disturbed. The different current can then be used to drive a vertical deflection amplifier in such a sense as to restore the current balance. Thus the spot can be constrained by servo action to move along the edge of the target electrode.

The tube has X plates, Y plates and a coil wound axially over the Y plates. The Y plates receive signals from a vertical deflection amplifier coupled to the target electrodes.

The X plates are fed through an amplifier with one of the signals to be multiplied. This imparts a transverse velocity to the electrons proportional to the input signal. The coil is fed with current which is proportional to the other input signal. This coil produces an axial magnetic field which interacts with the electrons by virtue of their transverse velocity. A vertical deflection force proportional to the product of field strength and transverse velocity therefore acts on the electrons. This is opposed by the servo action of the target electrodes and vertical deflection amplifier.

The voltage driving the Y plates is thus the product of the two input voltages.

4.3 Block Diagram

The Solartron Crossed Fields Multiplier Type TA721 is based upon the tube described in Section 4.2. The block diagram shows an X amplifier, a coil amplifier, a current inverter and a servo amplifier. A built-in stabilised EHT unit provides the accelerating potential for the electron gun.

The coil amplifier is a direct coupled feedback amplifier which provides the multiplier coil with current. To ensure that the current accurately follows the input signal, the multiplier coil is included in the feedback loop as shown in Fig. 3.

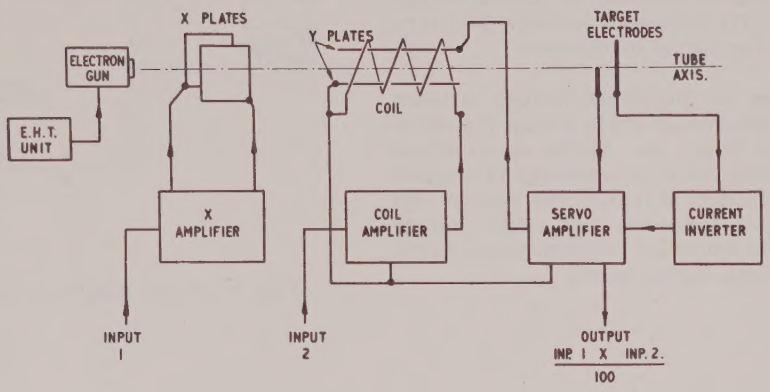

Fig. 2. Block Diagram of the Crossed Fields Multiplier

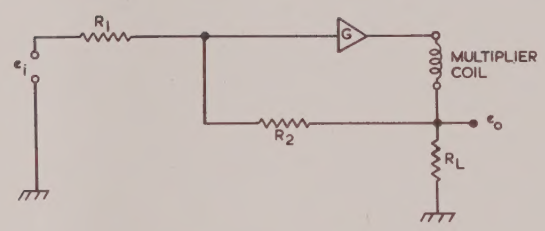

Fig. 3. Coil Amplifier Feedback Loop

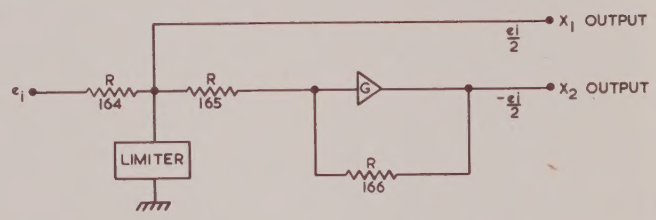

Fig. 4. 'X' Amplifier Feedback & Output Limiter

The amplifier has a high open loop gain. The ratio of $\frac{ei}{eo}$ is therefore controlled by the high stability input and feedback components R1 and R2.

Thus $eo = - ei \frac{R1}{R2}$

Neglecting the current in R1 and R2.

The current in R_L and thus in the coil is

$$\frac{eo}{R_L} = - \frac{ei}{R_L} \frac{R1}{R2} = Kei$$

when K is a constant.

The 'X' amplifier is a direct coupled unity gain, negative feedback amplifier which operates as a phase inverter. The feedback arrangements are shown in Fig. 4.

The output voltage taken from the amplifier is $\frac{-ei}{2}$ and that from the junction of R164 and R165 is $\frac{ei}{2}$. Thus a push pull deflection voltage is obtained to drive the 'X' plates of the tube. A voltage limiting device is connected to the junction of R164 and R165. This limits the maximum output voltage to 105 Volts.

The Current inverter is a direct coupled negative feedback amplifier which provides an output current equal in magnitude to but reversed in direction from the input current. The feedback arrangements are shown in Fig. 5. This amplifier has a high open loop gain and employs an auxiliary amplifier and chopper relay to reduce DC drifts to the order of 100μV. The correct output current is delivered when the output point is connected to the virtual earth of the servo amplifier.

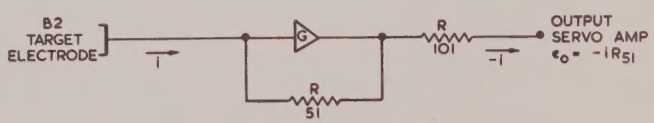

Fig. 5. Current Inverter Feedback Loop

The servo amplifier is a direct coupled negative feedback amplifier having a gain of approximately 50 Volts/μAmp. It employs an auxiliary amplifier and chopper relay to reduce drift. The feedback arrangements are shown in Fig. 6.

This amplifier develops an output voltage proportional to the difference between the currents from the two target electrodes.

A fraction of the output voltage is taken from the potentiometer chain to one Y plate of the multiplier tube. Due to the servo action described in Section 4.2, this voltage is proportional to the product of transverse velocity and field strength. Therefore the output voltage from the servo amplifier is proportional to the product of the two signal inputs.

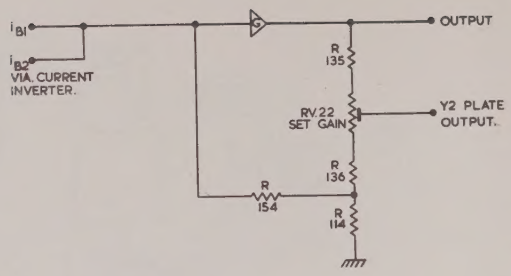

Fig. 6. Servo Amplifier Feedback Loop

DG

SECTION 5

CIRCUIT DESCRIPTION

5.1 Coil Amplifier

The coil amplifier comprises three stages of gain followed by an economy cathode follower. The first stage is V1, a double triode type CV492 (12AX7). This is connected as a differential amplifier, one grid receiving the input signal through the input resistor R1 and the other grid being connected through the resistor chain R10, R42, R43 and R13, between the ± 300 V rails. RV3 in this chain is the 'set coil current' control and controls the grid voltage of V1. The operating conditions of V1 are chosen to give minimum DC drift with changing conditions. The first anode (pin 1) is decoupled by C2 for frequencies above 30 c/s. The output is taken from the other anode (pin 6) through the resistive divider chain R15, R16, which is compensated for high frequency phase shift by C4. C3 and R14 are a gain and phase shaping network which ensures adequate stability in the amplifier. The signal output from the junction of R15 and R16 connects through the grid stopper R17 into V2A, one half of a double triode type CV455 (12AT7). The output from the anode of this valve is divided down in another resistive network R21 and R22. This network is compensated for HF phase shift by C6. The output at the junction of R21 R22 feeds into the cathode coupled stage V2B and V3. V3 is connected between the ± 300 V rails in order that adequate signal swing may be obtained at its anode. The output from this stage feeds direct into the grids of V4 a CV455 (12AT7) the economy cathode follower. This stage has as its cathode load the constant current valve V5 a CV455 (12AT7). The output from V4 is taken through the coil of the multiplier tube and back to earth through the resistor R5 across which the feedback voltage is developed. The negative feedback voltage is then fed through the feedback resistor R2 into the grid of V1.

The RF EHT unit is a simple feedback oscillator controlled by the screen grid potential. The rectified EHT is divided down through resistor chain and compared with a built-in neon voltage reference tube in a differential amplifier. The amplified output feeds through another stage of gain on to the screen grid of the oscillator giving EHT stabilisation.

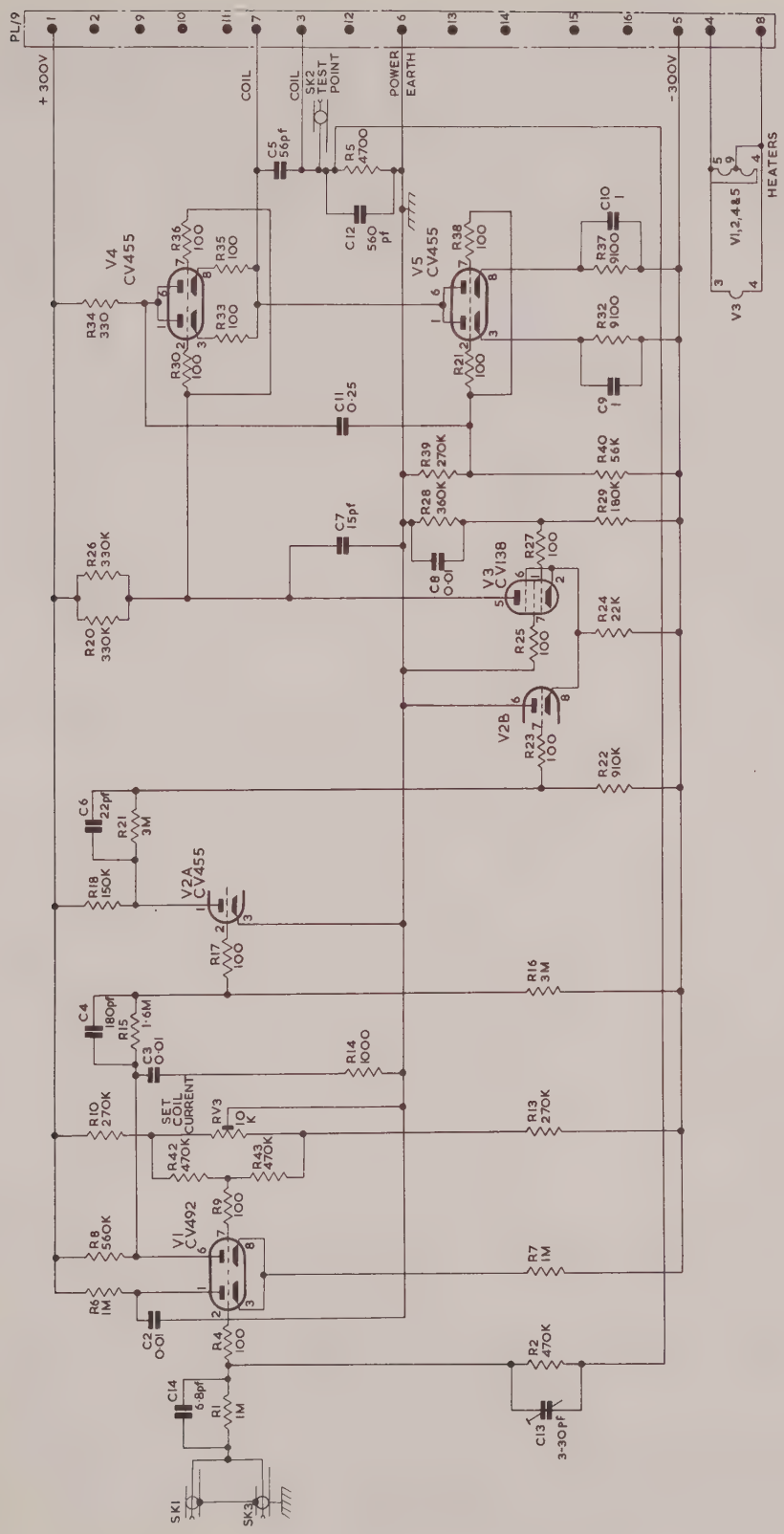

Fig. 7. Coil Amplifier Circuit Diagram

5.2 Current Inverter

The current inverter is a direct coupled drift-corrected amplifier. It contains a main amplifier with three stages of amplification and an economy cathode follower together with an auxiliary AC coupled drift-correcting amplifier with two stages of gain and a cathode follower.

The input stage V10 is a double triode type CV492 (12AX7) connected as a cathode coupled differential amplifier. The input current signal is connected to the input grid pin 7 through the grid stopper R52. The drift-correction signal from the auxiliary amplifier channel feeds into the grid pin 2 through the grid stopper R50. The operating conditions of this valve have been chosen to give minimum grid current. To obtain DC balance a small potentiometer RV10 is included in the cathode circuit. The anode (pin 6) is decoupled by C21 against frequencies above 30 c/s in order to prevent any Miller feedback from that anode to the input signal grid. The output from the other anode (pin 1) is divided down in the resistance chain R58, R57 and connected to the grid of V11 the second amplifying stage. C23 across R58 provides maximum coupling at the higher operating frequencies. C22 and R56 are a phase and gain shaping network necessary for stability. The output from the amplifier V11A a CV455 (12AT7) is divided down in the resistors R63 and R64 into the grid of V11B, which, with V12 forms a cathode coupled stage. C25 again provides maximum coupling at the higher operating frequencies and C24, R61 are a further phase and gain shaping network. V12 a CV138 (6AM6) is connected between the ± 300 V rails in order that it can adequately handle the required voltage swing. The output from the anode of this stage is coupled directly into the grid of V13B, the cathode follower. This has V13A type CV455 (12AT7) as its cathode load. V13A operates at a constant current which is determined by the grid potential (set by R76 and R77) and the value of its cathode load R74. This type of cathode follower gives considerable economy in HT current. C26, R69 in the grid circuit of V13B are provided as a third phase and gain shaping network. Negative feedback is taken from the cathode of V13B through the feedback resistor R51 to the input grid of V10. The summing junction of the main amplifier is connected to the auxiliary amplifier via R80. The relay A1 alternately earths and frees one end of R80 so that any input signal is chopped. The resulting square wave is fed to V14 via the network C30 and R96. This signal amplified in V14 an EF86 and again in V15A a CV492 (12AX7) before being fed into the cathode follower V15B. The output square wave then feeds through the coupling network C32 and R91 to the second contact of the chopper relay A1. The junction of R91, R92, R94 is thus alternately earthed and freed. This operation is exactly in anti-phase to the input chopping and results in an uni-directional square wave output which is smoothed by R93 and C34 to provide a DC drift-correction signal into the grid of V10.

The input signal to the Current Inverter is the current from one bucket electrode of the crossed fields multiplier tube.

This current flows through R51, the feedback resistor and as the summing junction current is negligible, the output voltage is that produced by the input current flowing in the feedback resistor. The output voltage from V13B is connected to the summing junction of the servo amplifier through a resistor equal in value to the feedback resistor. Thus a current flows into the summing junction of the servo amplifier equal in value and opposite in sign to the input current from the target electrode.

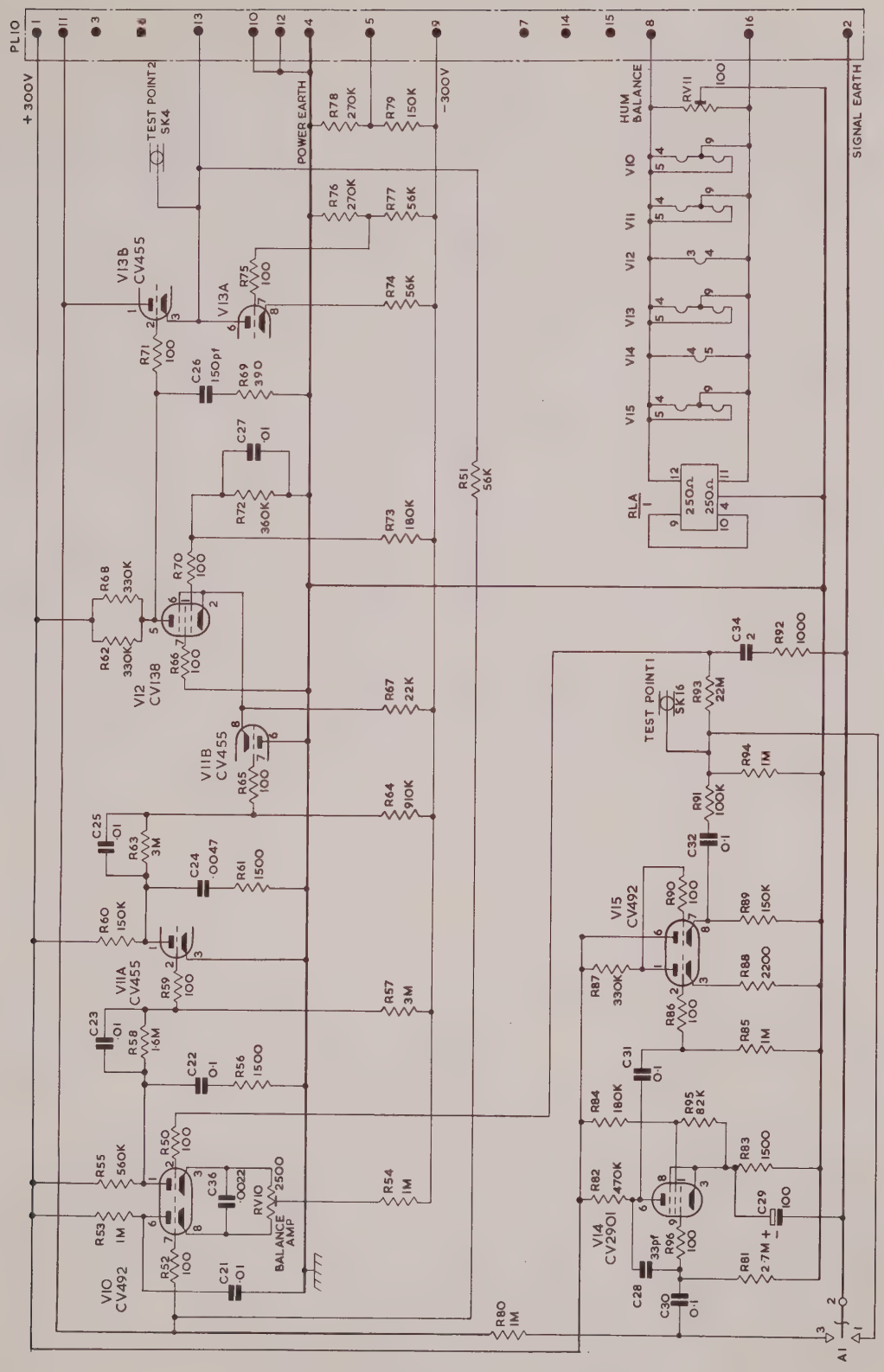

Fig. 8. Current Inverter Circuit Diagram

5.3 Servo Amplifier

This amplifier is similar in most respects to the current inverter. It is a DC drift-corrected amplifier whose input is the difference between the crossed fields multiplier tube target electrode currents. This difference current is applied to the input grid pin 2 of V20 a CV492 (12AX7). This stage is again a cathode coupled differential amplifier which receives an input signal on one grid and a drift-correcting signal from the auxiliary amplifier channel on the other grid. Conditions for this input stage are carefully chosen to give minimum grid current and a small potentiometer is connected between the two cathodes so that the output DC level can be set to zero. The anode of the input side of the valve is decoupled through C45 to eliminate Miller effect between this anode and the input signal grid. The output from the other anode is divided down into the grid of the second amplifying stage through R109 and R110. C47 provides maximum coupling at the higher operating frequencies. C46 and R108 form a phase and amplitude shaping network which is necessary for stability. The output from the second amplifying stage V21A a CV455 (12AT7) is divided down in a resistive network R115, R116. This network has C49 to provide HF coupling while C48 and R113 are another phase and gain shaping network necessary for stability. The output signal from V2/A drives the cathode coupled stage V21B, V22. In order that this stage may deliver adequate signal, the pentode V22, a CV138 (6AM6) is connected between ± 300V. C50 and R121 form the third phase and gain shaping network. The output from V22 amplifier feeds directly into the grids of V23 a CV455 (12AT7) a cathode follower. This stage has as its cathode load V24 a CV455 (12AT7) a constant current valve. The use of a constant current valve as the cathode load gives considerable economy in HT current. The output from the cathode follower V23 is first used to give signal output from the multiplier and secondly provides a deflection signal to one (Y2) plate of the crossed fields multiplier tube. Negative feedback is taken from a resistor chain between the output cathode and earth through the feedback resistor R154 to the input grid of V20. The summing junction of the main amplifier is connected to R137 the input resistor to the chopper channel. Any input signal is chopped by the relay B1 after the input resistor. This signal is fed to V25 as a square wave. V25 an EF86 and V26 a CV492 (12AX7) are two stages of AC coupled amplification. The output from V26A is directly coupled into the grid of V26B, a cathode follower. The square wave output from V26B is fed through C58 and R148 to the second contact of the relay B1. This point is alternately earthed and freed to provide an uni-directional square wave. This square wave is then smoothed in R150 and C60 to provide a DC drift correction signal on to the grid pin 7 of V20. The uni-directional square wave is also used to actuate an overload indicator when it becomes of large magnitude.

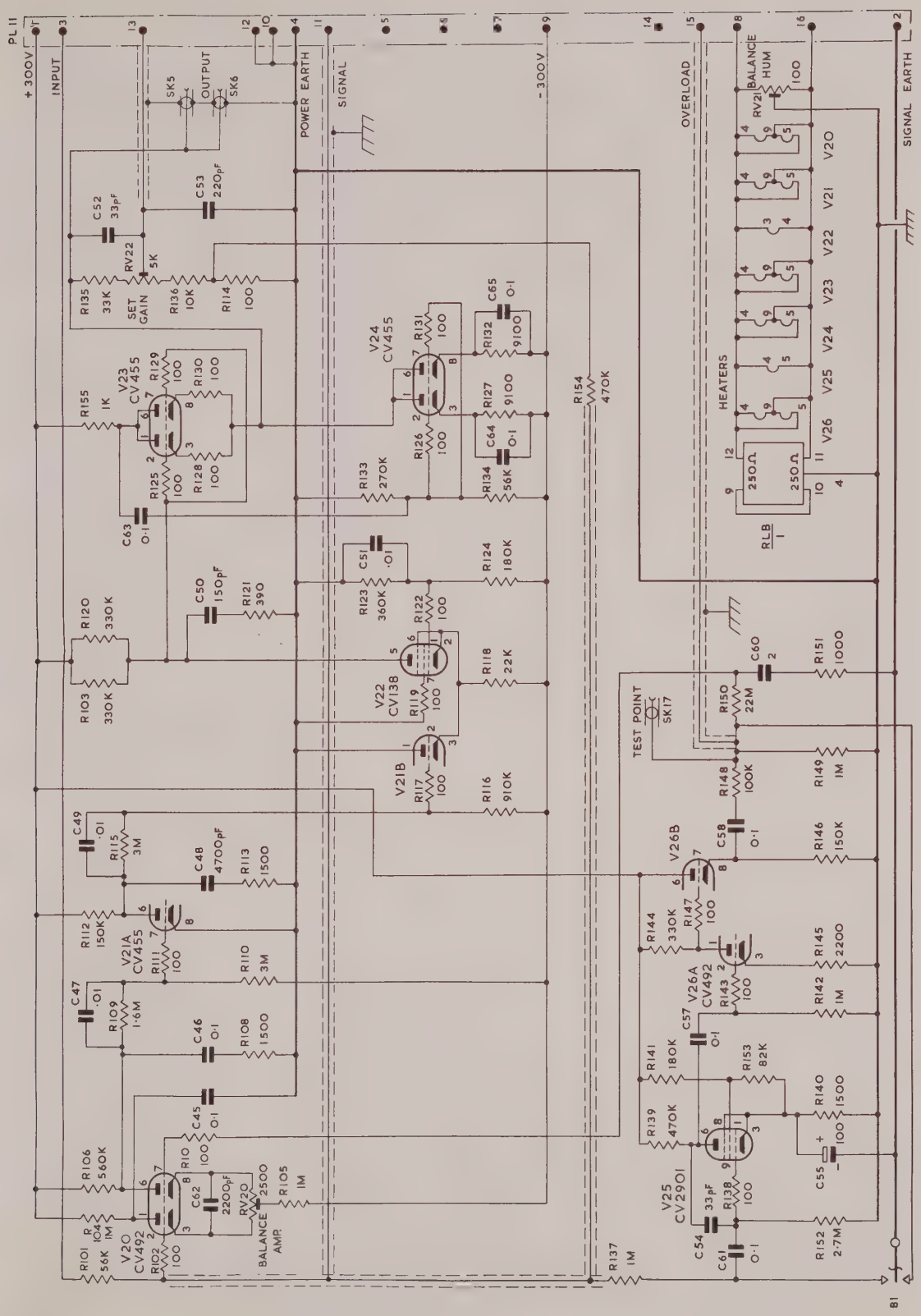

Fig. 9. Servo Amplifier Circuit Diagram

5.4 X Amplifier

This amplifier is a DC amplifier comprising three stages of gain and an economy cathode follower. The input to this stage is connected to one of the signals to be multiplied. It comes in on either a 3 mm socket or a coaxial socket and feeds directly on to the input resistor R164, which has C83 and C78 in parallel with it to give HF compensation against strong capacitance. The diodes V30A, V30B a CV140 (6AL5) are provided to limit the input signal so that the X input deflection voltage can never be great enough to move the electron beam outside the area covered by the target electrodes. The positive and negative potentials to which this swing is limited are determined by resistive networks R160, R161, R162 and R163 between the + 300 V and earth and earth and - 300 V rails respectively. The input signal which is also supplied to an X plate, then feeds through a second input resistor R165, with C82 in parallel to give HF compensation, into the input grid of V31 a CV492 (12AX7). This input stage is again a cathode coupled differential amplifier but in this instance the free grid is earthed. The conditions under which this valve operates are carefully selected to give minimum grid current and the anode of the input side of the valve is decoupled through C72 to eliminate Miller effect between this anode and the input grid. RV30 in the cathode circuit is provided to balance the output signal at zero. The output signal from this stage is divided down in R179, R180 into the grid of the second amplifying stage V32A. C74 is provided to give HF compensation for stray capacitance and C73, R173 are a phase and amplitude shaping network necessary for stability. The output of V32 a CV455 (12AT7) is divided down in R183 and R184 into the grid of V32B. C75 provides HF coupling. V32B and V33 a CV138 (6AM6) form a cathode coupled stage. The grid of V33 is held at a potential between the - 300 V rail and earth determined by R191 and R192. This point is decoupled to earth against AC signals by C77. The output of V33 is directly coupled into the input of V34A a CV455 (12AT7) the output cathode follower. This stage has V34B, a constant current valve, in its cathode as the cathode load, thus effecting a considerable saving in HT current. C76 and R189 are the third phase and amplitude shaping network. The output from the output cathode follower drives one of the X plates of the crossed fields multiplier tube. Negative feedback is taken from this cathode through R166 and C79, an HF compensating capacitor, to the input grid pin 2 of V31. The second Y plate Y1 of the crossed fields multiplier tube is also connected into this unit. Its DC potential is determined by a network of resistors comprising R104 and R201, and coarse adjustment is by the potentiometer RV31. Fine adjustment is effected by an additional network on the main frame. There is also provision for hum balancing by means of the potentiometer RV32. This is used to balance out any hum introduced in the Current inverter and Servo Amplifiers.

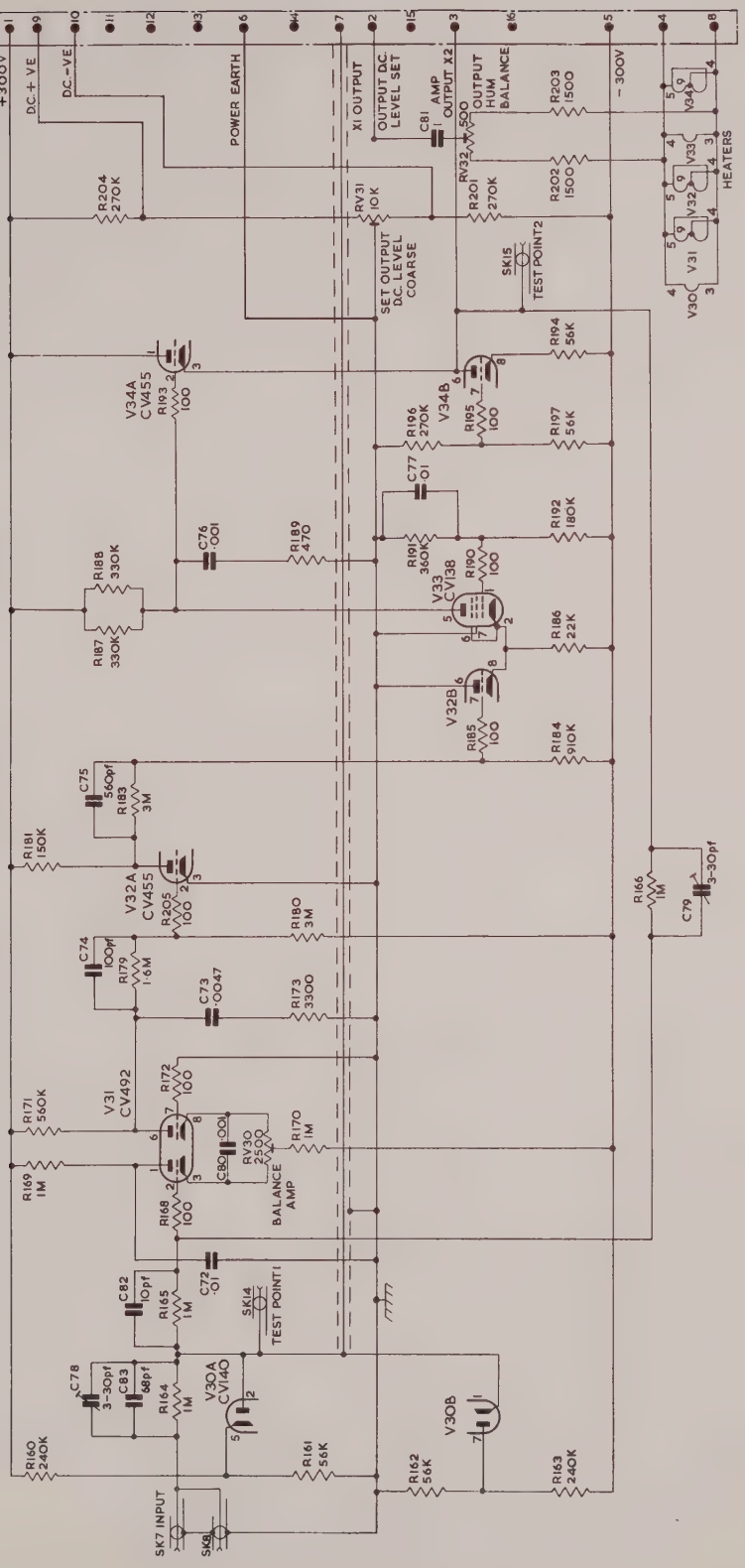

Fig. 10. 'X' Amplifier Circuit Diagram

5.5 EHT Unit

V40 a CV138 (6AM6) is a pentode connected as a tuned anode oscillator with transformer coupling from anode to grid. A third winding on the transformer feeds the EHT rectifier V44 a CV426 (R12).

The positive of the rectified output is connected to - 300 V while the negative is smoothed by C93, R211, C95 and feeds the EHT potentials to the multiplier tube. A portion of the EHT voltage is fed back through a resistive chain into the grid of V42 a CV455 (12AT7) which is a cathode coupled differential amplifier. The other grid of this stage is referred to - 85 Volts by means of a neon voltage reference tube V43 a CV449 (85A2) thus any variations in the EHT voltage will create a difference signal in V42. This signal is amplified and directly coupled into V41B a CV455 (12AT7) where it is further amplified before being directly coupled into V41A. V41A is a cathode follower in which the cathode current flows through the screen of the oscillator valve V40. Any variations of EHT voltage will therefore vary the screen voltage of V40, the oscillator valve, in such a sense as to correct the original variation of EHT. RV40 in the EHT feedback network is provided to accurately set the EHT voltage.

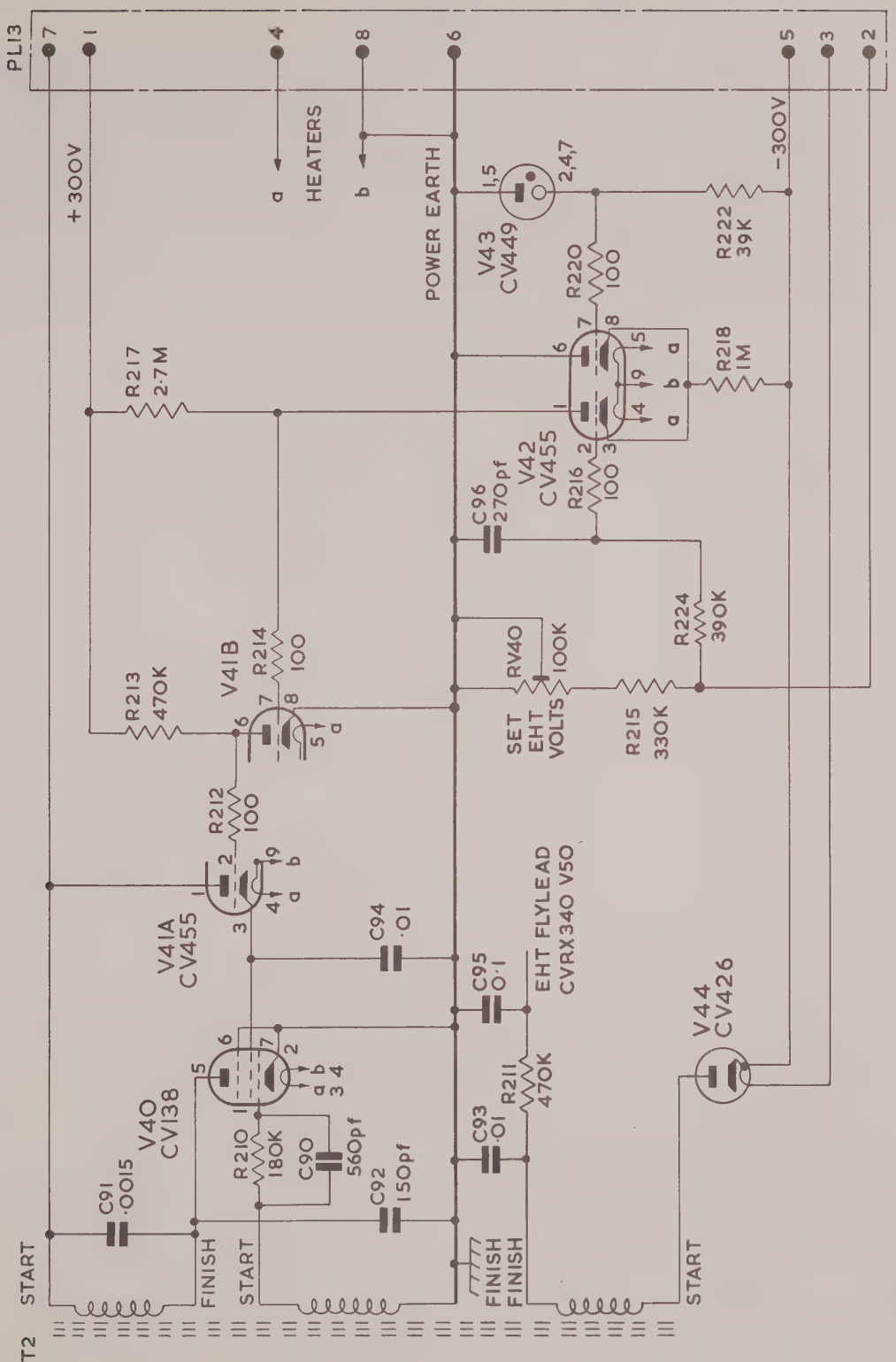

Fig. 11. E. H. T. Unit Circuit Diagram

5.6 The Main Frame

The main frame which houses the five sub-units previously described also carries the heater transformer, the multiplier tube and the plugs and sockets providing the various services to the sub-units. The multiplier tube has already been described in detail and no further description need be given here. The heater transformer has a universal primary enabling it to be operated from 110 or 220 V ± 20 V 50 - 60 c/s mains. It has seven 6.3 V secondaries of various current ratings, which drive the valve heaters in the various sections of the equipment. LP1 connected between the servo amplifier socket SK11 and the power earth is the overload indicator. LP2 is the mains on indicator. One half of the double triode V51 a CV492 (12AX7) is a constant current device which stabilises the current through the multiplier tube. Fine adjustment of the DC potential applied to the Y1 plate of the multiplier tube by the X amplifier, is effected by the potentiometer RV51 included in the resistor chain R241 and R242. This is mounted on the front panel.

SECTION 6

SETTING UP PROCEDURE

6.1 Equipment

The following items of test equipment will be needed.

(a) Avometer Model 8

(b) Oscillator Type CO546

(c) Oscilloscope Type CD513

(d) DC Amplifier Type AA621.2

(e) ± 100 Volt Reference Supply Type AS756.2

6.2 Physical Configuration

The Crossed Fields Multiplier consists of a main chassis carrying the multiplier tube type 490CAX with its associated coil and double mu-metal shield, a heater transformer and circuitry associated with the EHT supply to the tube. Five sub-units are plugged into the main chassis. Viewed from the rear of the chassis the units are the coil amplifier, the current inverter, the servo amplifier, the X amplifier and the EHT unit in order from left to right. Connections to the main chassis are made by means of McMurdo plugs and sockets. On the EHT unit there is an extra connection made through a flying lead connector. On the extreme right hand side of the main chassis is the supply distribution panel. This carries the Mains Selector Panel, which should be adjusted to correspond with the local mains supply voltage. It also carries the HT supply plug PL6 and the mains input power supply plug.

6.3 Setting Up of Individual Units

6.3.1 For the initial setting up of individual units it is recommended that all units be removed from the main chassis except the actual unit being set up. As the units are mechanically interchangeable care should be taken to ensure that the units are plugged only into their correct positions. When inserting or removing units from the main chassis, or when making connections for measuring purposes to points other than the panel mounted sockets, the HT supplies must be switched off. In sections 6.3.2 to 6.3.5 it is assumed that the appropriate unit has been plugged in, the connections to the measuring instruments made and the HT supplies switched on.

6.3.2 On the EHT unit measure the voltage between the junction of R211 (470 kilohms) and C95 (0.1 micro-Farads) and Power Earth (henceforth abbreviated to PE) on the 2,500 volt range of the Avometer. Adjust the Set EHT volts control until the voltage is 1,500 volts negative.

6.3.3 On the X Amplifier connect the Input socket to Signal Earth (henceforth abbreviated to SE) and measure the DC voltage between Test Point 2 and SE with the Avometer. Adjust the Balance Amp. control until the voltage is zero within say 0.1 volt.

Fig. 12. Hum Adjustment Waveforms at Test Points SK16 & 17

6.3.4 On the Servo Amplifier observe the hum voltage at the Output socket with the oscilloscope. Adjust the Hum Balance control to minimise the hum voltage. Observe the waveform at the Test Point. This should have the appearance of Fig.12 Adjust the Balance Amp control until the waveform is judged to have zero DC content as in Fig. 13

Fig. 13. Balance Amplifier Adjustment Waveforms at Test Points SK16 & 17

6.3.5 On the Current Inverter observe the hum voltage at the Test Point 2 socket with the oscilloscope. Adjust the Hum Balance control to minimise the hum voltage. Observe the waveform at Test Point 1. This should have the appearance of Fig.12 above. Adjust the Balance Amp control until the waveform is judged to have zero DC content as in Fig.13.

6.4 Setting Up of Complete Multiplier

6.4.1 Insert all the units and connect the flying lead to the EHT unit. Switch on the HT supplies. Approximately 30 minutes should be allowed for the multiplier tube type 490CAX to reach thermal equilibrium.

6.4.2 Connect input and feedback resistors of 100 kilohms and 1 Meg-ohm respectively to the DC amplifier thus making the gain from input to output 10 X. Connect the output of the oscillator to the input of the DC amplifier and set the oscillator frequency to 100 c/s. Adjust the output amplitude of the oscillator until the amplitude at the output of the DC amplifier is 200 volts peak to peak, measured on the oscilloscope. The sinusoidal voltage obtained from the output of the DC amplifier will, throughout the remainder of these procedures, be referred to as the Drive Signal.

Connect the Drive Signal to the X input terminal of the oscilloscope through the resistance-capacitance network, shown in Fig.14 and switch the oscilloscope time base to EXT. C1 should be adjusted so that there is equal phase shift in the X and Y channels of the oscilloscope. For this purpose connect the Drive Signal to the Y input terminal of the oscilloscope and increase the frequency of the Drive Signal to 1000 c/s. Adjust C1 until the elliptical trace on the oscilloscope screen degenerates into a straight line. Disconnect the drive signal from the Y input terminal and reset the oscillator frequency to 100 c/s. The connection to the X input terminal of the oscilloscope is maintained for the remainder of these procedures.

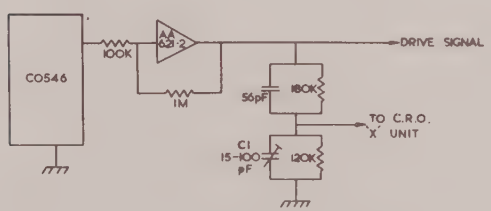

Fig. 14. Setting Up Network

6.4.3 DC Coil Current Setting

Connect the Input socket of the Coil Amplifier to SE. Apply the Drive Signal to the Input socket of the X Amplifier. Observe the voltage at the Output socket of the Servo Amplifier with the oscilloscope. Adjust the Set Coil Current control on the Coil Amplifier until the trace on the oscilloscope screen is horizontal. Adjust the Focus control on the right hand side of the main chassis for optimum definition and minimum curvature of the trace. A compromise may be necessary. Remove the connections to the Coil Amplifier and the X Amplifier.

6.4.4 Mechanical Setting of Multiplier Tube

Connect the Input socket of the X Amplifier to SE. Apply the Drive Signal to the Input socket of the Coil Amplifier. Observe the voltage at the Output socket of the Servo Amplifier with the oscilloscope. Adjust the mechanical position of the multiplier tube, using the two 2B.A. screws with nuts and lock-nuts, which project through the mu-metal shield, until a horizontal trace is obtained on the oscilloscope screen. The screw at the top (left hand) end of the tube rotates the trace whilst the screw at the base (right hand) end of the tube controls the curvature of the trace. Remove the connections to the Coil Amplifier and the X Amplifier.

6.4.5 DC Output Level Setting

Connect the Input socket of the Coil Amplifier and the Input socket of the X Amplifier to SE. Measure the DC voltage between the Output socket of the Servo Amplifier and the SE with the Avometer. Adjust the Set Output DC Level control on the X Amplifier and the Set Level Fine control on the main chassis, until the voltage is zero within say 0.1 volt. Observe the voltage at the Output socket with the oscilloscope and adjust the Output Hum Balance control on the X Amplifier to minimise the hum voltage. Remove the connections to the X Amplifier and the Coil Amplifier.

6.4.6 Gain (Scale Factor) Setting

Connect the +100 Volt output of the ± 100 Volt Reference Supply to the Input socket of the X Amplifier and the Input socket of the Coil Amplifier. Connect the positive terminal of the Avometer to the Output socket of the Servo Amplifier and connect the negative terminal of the Avometer to the + 100 Volt reference supply. Adjust the Set Gain control on the Servo Amplifier until the Avometer reads zero DC voltage within say 0.1 volt. Measure the errors of multiplication with the connections to the Reference Supply shown in Table 1. The errors should be less than 1 volt.

TABLE 1

X Amplifier Input	Coil Amplifier Input	Negative Terminal of Avometer
+ 100 volts	- 100 volts	- 100 volts
- 100 volts	+ 100 volts	- 100 volts
- 100 volts	- 100 volts	+ 100 volts

After noting the errors a slight readjustment of the Set Gain control may be made to minimise the average error modulus, at the four combinations of + 100 volts or - 100 volts input given above. Remove the connections to the Coil Amplifier the X Amplifier and the Servo Amplifier.

6.4.7 Phase Shift Compensation in Coil Amplifier

Connect the Drive Signal to the Input socket of the Coil Amplifier and connect the + 100 volts reference supply to the Input socket of the X Amplifier. Cbserve the voltage at the Output terminal of the Servo Amplifier with the oscilloscope. Adjust the variable capacitor C13 in the Coil Amplifier until the elliptical trace on the oscilloscope screen degenerates into a straight line. Remove the connections to the Coil Amplifier, the X Amplifier and the Servo Amplifier.

6.4.8 Phase Shift Compensation in X Amplifier

Connect the Drive Signal to the Input socket of the X Amplifier and connect the + 100 volts reference supply to the Input socket of the Coil Amplifier. Observe the voltage at Test Point 1 on the X Amplifier with the oscilloscope and adjust the variable capacitor C78 in the X Amplifier until the elliptical trace on the oscilloscope screen degenerates into a straight line. Observe the voltage at Test Point 2 on the X Amplifier and adjust C79 for similar results. Observe the voltage at the Cutput socket of the Servo Amplifier and re-adjust C78 until the elliptical trace degenerates into a straight line. Remove the connections to the X Amplifier, the Coil Amplifier and the Servo Amplifier.

COMPONENT LIST

Circuit Ref.	Value Ohms	Tolerance %	Manufacturer & Type		Rating Watts	Solartron Part No.
R 1	1M	1	Painton	74 H.S.	3/4	224314
R 2	470K	1	Erie	109 H.S.	1/8	221089
R 3	Not fitted					
R 4	100	10	Erie	9 Carbon	1/4	226313
R 5	4700	1	Painton	P406A W.W.	3	238265
R 6	1M	10	Erie	9 Carbon	1/4	226361
R 7	1M	2	Painton	74 H.S.	3/4	224514
R 8	560K	2	Painton	74 H.S.	3/4	224508
R 9	100	10	Erie	9 Carbon	1/4	226313
R10	270K	2	Painton	74 H.S.	3/4	224500
R11	Not fitted					
R12	Not fitted					
R13	270K	2	Painton	74 H.S.	3/4	224500
R14	1000	10	Erie	9 Carbon	1/4	226325
R15	1.6M	1	Painton	74 H.S.	1	224319
R16	3M	2	Painton	74 H.S.	3/4	224525
R17	100	10	Erie	9 Carbon	1/4	226313
R18	150K	10	Erie	8 Carbon	1/2	226551
R19	Not fitted					
R20	330K	10	Erie	8 Carbon	1/2	226555
R21	3M	2	Painton	74 H.S.	3/4	224525
R22	910K	1	Painton	74 H.S.	3/4	224313
R23	100	10	Erie	9 Carbon	1/4	226313
R24	22K	2	Painton	74 H.S.	3/4	224474
R25	100	10	Erie	9 Carbon	1/4	226313
R26	330K	10	Erie	8 Carbon	1/2	226555
R27	100	10	Erie	9 Carbon	1/4	226313
R28	360K	2	Erie	109 H.S.	1/8	221186
R29	180K	2	Erie	109 H.S.	1/8	221179
R30	100	10	Erie	9 Carbon	1/4	226313
R31	100	10	Erie	9 Carbon	1/4	226313
R32	9100	2	Painton	74 H.S.	3/4	224465
R33	100	10	Erie	9 Carbon	1/4	226313
R34	330	10	Erie	9 Carbon	1/4	226319
R35	100	10	Erie	9 Carbon	1/4	226313
R36	100	10	Erie	9 Carbon	1/4	226313
R37	9100	2	Painton	74 H.S.	3/4	224465
R38	100	10	Erie	9 Carbon	1/4	226313
R39	270K	2	Erie	109 H.S.	1/8	221183
R40	56K	2	Erie	109 H.S.	1/8	221167
R41	Not fitted					
R42	470K	2	Erie	109 H.S.	1/8	221189
R43	470K	2	Erie	109 H.S.	1/8	221189
R50	100	1	Erie	9 Carbon	1/4	226313
R51	56K	1	Erie	109 H.S.	1/8	221067
R52	100	10	Erie	9 Carbon	1/4	226313
R53	1M	10	Erie	9 Carbon	1/4	226361
R54	1M	2	Painton	74 H.S.	3/4	224514

Circuit Ref.	Value Ohms	Tolerance %	Manufacturer & Type		Rating Watts	Solartron Part No.
R55	560K	2	Painton	74 H.S.	3/4	224508
R56	1500	10	Erie	9 Carbon	1/4	226327
R57	3M	2	Painton	74 H.S.	3/4	224525
R58	1.6M	2	Painton	74 H.S.	3/4	224519
R59	100	10	Erie	9 Carbon	1/4	226313
R60	150K	10	Erie	8 Carbon	1/2	226551
R61	1500	10	Erie	9 Carbon	1/4	226327
R62	330K	10	Erie	8 Carbon	1/2	226555
R63	3M	2	Painton	74 H.S.	3/4	224525
R64	910K	1	Painton	74 H.S.	3/4	224313
R65	100	10	Erie	9 Carbon	1/4	226313
R66	100	10	Erie	9 Carbon	1/4	226313
R67	22K	2	Painton	74 H.S.	3/4	224474
R68	330K	10	Erie	8 Carbon	1/2	226555
R69	390	10	Erie	9 Carbon	1/4	226320
R70	100	10	Erie	9 Carbon	1/4	226313
R71	100	10	Erie	9 Carbon	1/4	226313
R72	360K	1	Erie	109 H.S.	1/8	221086
R73	180K	1	Erie	109 H.S.	1/8	221079
R74	56K	10	Erie	9 Carbon	1/4	226346
R75	100	10	Erie	9 Carbon	1/4	226313
R76	270K	2	Erie	109 H.S.	1/8	221183
R77	56K	2	Erie	109 H.S.	1/8	221167
R78	270K	10	Erie	9 Carbon	1/4	226354
R79	150K	10	Erie	9 Carbon	1/4	226351
R80	1M	10	Erie	9 Carbon	1/4	226361
R81	2.7M	10	Erie	9 Carbon	1/4	226366
R82	470K	10	Erie	9 Carbon	1/4	226357
R83	1500	10	Erie	9 Carbon	1/4	226327
R84	180K	10	Erie	8 Carbon	1/2	226552
R85	1M	10	Erie	9 Carbon	1/4	226361
R86	100	10	Erie	9 Carbon	1/4	226313
R87	330K	10	Erie	9 Carbon	1/4	226355
R88	2200	10	Erie	9 Carbon	1/4	226329
R89	150K	10	Erie	9 Carbon	1/4	226351
R90	100	10	Erie	9 Carbon	1/4	226313
R91	100K	10	Erie	9 Carbon	1/4	226349
R92	1M	10	Erie	9 Carbon	1/4	226361
R93	22M	20	Erie	9 Carbon	1/4	N22277
R94	1000	10	Erie	9 Carbon	1/4	226325
R95	82K	10	Erie	9 Carbon	1/4	226348
R96	100	10	Erie	9 Carbon	1/4	226313
R101	56K	1	Erie	109 H.S.	1/8	221067
R102	100	10	Erie	9 Carbon	1/4	226313
R103	330K	10	Erie	8 Carbon	1/2	226555
R104	1M	10	Erie	9 Carbon	1/4	226361
R105	1M	2	Painton	74 H.S.	3/4	224514
R106	560K	2	Painton	74 H.S.	3/4	224508
R107	100	10	Erie	9 Carbon	1/4	226313
R108	1500	10	Erie	9 Carbon	1/4	226327
R109	1.6M	1	Painton	74 H.S.	3/4	22431
R110	3M	2	Painton	74 H.S.	3/4	224525

Circuit Ref.	Value Ohms	Tolerance %	Manufacturer & Type		Rating Watts	Solartron Part No.
R111	100	10	Erie	9 Carbon	1/4	226313
R112	150K	10	Erie	8 Carbon	1/2	226551
R113	1500	10	Erie	9 Carbon	1/4	226327
R114	100	10	Erie	9 Carbon	1/4	226313
R115	3M	2	Painton	74 H.S.	3/4	224525
R116	910K	1	Painton	74 H.S.	3/4	224313
R117	100	10	Erie	9 Carbon	1/4	226313
R118	22K	2	Painton	74 H.S.	3/4	224474
R119	100	10	Erie	9 Carbon	1/4	226313
R120	330K	10	Erie	8 Carbon	1/2	226555
R121	390	10	Erie	9 Carbon	1/4	226320
R122	100	10	Erie	9 Carbon	1/4	226313
R123	360K	2	Erie	109 H.S.	1/8	221186
R124	180K	2	Erie	109 H.S.	1/8	221179
R125	100	10	Erie	9 Carbon	1/4	226313
R126	100	10	Erie	9 Carbon	1/4	226313
R127	9100	2	Painton	74 H.S.	3/4	224465
R128	100	10	Erie	9 Carbon	1/4	226313
R129	100	10	Erie	9 Carbon	1/4	226313
R130	100	10	Erie	9 Carbon	1/4	226313
R131	100	10	Erie	9 Carbon	1/4	226313
R132	9100	2	Painton	74 H.S.	3/4	224465
R133	270K	2	Erie	109 H.S.	1/8	221183
R134	56K	2	Erie	109 H.S.	1/8	221167
R135	33K	2	Erie	109 H.S.	1/8	221161
R136	10K	2	Erie	109 H.S.	1/8	221149
R137	1M	10	Erie	9 Carbon	1/4	226361
R138	100	10	Erie	9 Carbon	1/4	226313
R139	470K	10	Erie	9 Carbon	1/4	226357
R140	1500	10	Erie	9 Carbon	1/4	226327
R141	180K	10	Erie	8 Carbon	1/2	226552
R142	1M	10	Erie	9 Carbon	1/4	226361
R143	100	10	Erie	9 Carbon	1/4	226313
R144	330K	10	Erie	9 Carbon	1/4	226355
R145	2200	10	Erie	9 Carbon	1/4	226329
R146	150K	10	Erie	9 Carbon	1/4	226351
R147	100	10	Erie	9 Carbon	1/4	226313
R148	100K	10	Erie	9 Carbon	1/4	226349
R149	1M	10	Erie	9 Carbon	1/4	226361
R150	22M	20	Erie	9 Carbon	1/4	N22277
R151	1000	10	Erie	9 Carbon	1/4	226325
R152	2.7M	10	Erie	9 Carbon	1/4	226366
R153	82K	10	Erie	9 Carbon	1/4	226348
R154	470K	10	Erie	9 Carbon	1/4	226357
R155	1000	10	Erie	9 Carbon	1/4	226325
R160	240K	2	Erie	109 H.S.	1/8	221182
R161	56K	2	Erie	109 H.S.	1/8	221167
R162	56K	2	Erie	109 H.S.	1/8	221167
R163	240K	2	Erie	109 H.S.	1/8	221182
R164	1M	1	Painton	74 H.S.	3/4	224314

Circuit Ref.	Value Ohms	Tolerance %	Manufacturer & Type		Rating Watts	Solartron Part No.
R165	1M	1	Painton	74 H.S.	$\frac{3}{4}$	224314
R166	1M	1	Painton	74 H.S.	$\frac{3}{4}$	224314
R167	Not fitted					
R168	100	10	Erie	9 Carbon	$\frac{1}{4}$	226313
R169	1M	10	Erie	9 Carbon	$\frac{1}{4}$	226361
R170	1M	2	Painton	74 H.S.	$\frac{3}{4}$	224514
R171	560K	2	Painton	74 H.S.	$\frac{3}{4}$	224508
R172	100	10	Erie	9 Carbon	$\frac{1}{4}$	226313
R173	3300	10	Erie	9 Carbon	$\frac{1}{4}$	226331
R174	Not fitted					
R175	Not fitted					
R176	Not fitted					
R177	Not fitted					
R178	Not fitted					
R179	1.6M	1	Painton	74 H.S.	$\frac{3}{4}$	224319
R180	3M	2	Painton	74 H.S.	$\frac{3}{4}$	224525
R181	150K	10	Erie	8 Carbon	$\frac{1}{2}$	226551
R182	Not fitted					
R183	3M	2	Painton	74 H.S.	$\frac{3}{4}$	224525
R184	910K	1	Painton	74 H.S.	$\frac{3}{4}$	224313
R185	100	10	Erie	9 Carbon	$\frac{1}{4}$	226313
R186	22K	2	Painton	74 H.S.	$\frac{3}{4}$	224474
R187	330K	10	Erie	8 Carbon	$\frac{1}{2}$	226555
R188	330K	10	Erie	8 Carbon	$\frac{1}{2}$	226555
R189	470	10	Erie	9 Carbon	$\frac{1}{4}$	226321
R190	100	10	Erie	9 Carbon	$\frac{1}{4}$	226313
R191	360K	2	Erie	109 H.S.	1/8	221186
R192	180K	2	Erie	109 H.S.	1/8	221179
R193	100	10	Erie	9 Carbon	$\frac{1}{4}$	226313
R194	56K	10	Erie	9 Carbon	$\frac{1}{4}$	226346
R195	100	10	Erie	9 Carbon	$\frac{1}{4}$	226313
R196	270K	2	Erie	109 H.S.	1/8	221183
R197	56K	2	Erie	109 H.S.	1/8	221167
R198	Not fitted					
R201	270K	2	Painton	74 H.S.	$\frac{3}{4}$	224500
R202	1500	2	Erie	109 H.S.	1/8	221129
R203	1500	2	Erie	109 H.S.	1/8	221129
R204	270K	2	Painton	74 H.S.	$\frac{3}{4}$	224500
R205	100	10	Erie	9 Carbon	$\frac{1}{4}$	226313
R210	180K	10	Erie	9 Carbon	$\frac{1}{4}$	226352
R211	470K	10	Erie	9 Carbon	$\frac{1}{4}$	226357
R212	100	10	Erie	9 Carbon	$\frac{1}{4}$	226313
R213	470K	10	Erie	9 Carbon	$\frac{1}{4}$	226357
R214	100	10	Erie	9 Carbon	$\frac{1}{4}$	226313
R215	330K	2	Erie	109 H.S.	1/8	221185
R216	100	10	Erie	9 Carbon	$\frac{1}{4}$	226313
R217	2.7M	10	Erie	9 Carbon	$\frac{1}{4}$	226366
R218	1M	10	Erie	9 Carbon	$\frac{1}{4}$	226361
R219	Not fitted					

Circuit Ref.	Value Ohms	Tolerance %	Manufacturer & Type		Rating Watts	Solartron Part No.
R220	100	10	Erie	9 Carbon	$\frac{1}{4}$	226313
R221	Not fitted					
R222	39K	5	Painton	P305A W.W.	6	239044
R223	Not fitted					
R224	390K	10	Erie	9 Carbon	$\frac{1}{4}$	226356
R230	1000	10	Erie	9 Carbon	$\frac{1}{4}$	226325
R231	100K	10	Erie	9 Carbon	$\frac{1}{4}$	226349
R232	910K	2	Painton	74 H.S.	$\frac{3}{4}$	224513
R233	910K	2	Painton	74 H.S.	$\frac{3}{4}$	224513
R234	910K	2	Painton	74 H.S.	$\frac{3}{4}$	224513
R235	270K	2	Erie	109 H.S.	1/8	221183
R236	120K	2	Erie	109 H.S.	1/8	221175
R237	2.7M	2	Painton	74 H.S.	$\frac{3}{4}$	224524
R238	910K	2	Painton	74 H.S.	$\frac{3}{4}$	224513
R239	820K	2	Painton	74 H.S.	$\frac{3}{4}$	224512
R240	910K	2	Painton	74 H.S.	$\frac{3}{4}$	224513
R241	470K					221189
R242	470K					221189
RV3	10K	10	Colvern	CLR4201/9S W.W.	1	256613
RV10	2500	10	Colvern	CLR1206/9S W.W.	$\frac{1}{2}$	256411
RV11	100	10	Colvern	CLR1206/9S W.W.	$\frac{1}{2}$	256407
RV20	2500	10	Colvern	CLR1206/9S W.W.	$\frac{1}{2}$	256411
RV21	100	10	Colvern	CLR1206/9S W.W.	$\frac{1}{2}$	256407
RV22	5000	10	Colvern	CLR1206/9S W.W.	$\frac{1}{2}$	256412
RV30	2500	10	Colvern	CLR1206/9S W.W.	$\frac{1}{2}$	256411
RV31	10K	10	Colvern	CLR1206/9S W.W.	$\frac{1}{2}$	256413
RV32	500	10	Colvern	CLR1206/9S W.W.	$\frac{1}{2}$	256409
RV40	100K	10	Colvern	CLR4201/9S W.W.	1	256616
RV50	100K	10	Colvern	CLR4201/9S W.W.	1	256616
RV51	100K					256666

Circuit Ref.	Value pF	Tolerance %	Manufacturer & Type		Rating Volts	Solartron Part No.
C 1	Not fitted					
C 2	0.01μF	10	Suflex	Po	500	N20247
C 3	0.01μF	10	Suflex	Po	500	N20247
C 4	180	2	Suflex	HS Po	500	217428
C 5	56	2	Suflex	HS Po	500	217422
C 6	22	10	Suflex	HS Po	500	217609
C 7	15	10	Suflex	HS Po	500	217608
C 8	0.01μF	10	Suflex	Po	500	N20247
C 9	1μF	25	Hunt	B503 MP	150	206504
C10	1μF	25	Hunt	B503 MP	150	206504
C11	0.25μF	20	Hunt	B410 MP	500	N20203
C12	560	2	Suflex	HS Po	500	217434
C13	3-30		Mullard	E7876 Var.	75	240002
C14	6.8	.5	Suflex	HS Po	500	N20107
C21	0.01μF	10	Suflex	Po	500	N20247
C22	0.1μF	25			350	206703
C23	0.01μF	10	Suflex	Po	500	N20247
C24	0.0047μF	10	Suflex	HS Po	500	217623

Circuit Ref.	Value pF	Tolerance %	Manufacturer & Type		Rating Volts	Solartron Part No.
C25	0.01μF	10	Suflex	Po	500	N20247
C26	150	10	Suflex	HS Po	500	217614
C27	0.01μF	10	Suflex	Po	500	N20247
C28	33	10	Suflex	HS Po	500	217610
C29	100μF		T. C. C.	CE59AE El	6	N20194
C30	0.1μF	25	Hunt	B506 M. Pa	250	206602
C31	0.1μF	25	Hunt	B512 M. Pa	350	206703
C32	0.1μF	25	Hunt	B506 M. Pa	250	206602
C33	Not fitted					
C34	2μF	25	Hunt	B503 MP	150	206505
C35	Not fitted					
C36	0.0022μF	10	Suflex	HS Po	500	217621
C45	0.1μF	25	Hunt	B512 M. Pa	350	206703
C46	0.1μF	25	Hunt	B512 M. Pa	350	206703
C47	0.01μF	10	Suflex	Po	500	N20247
C48	0.0047μF	10	Suflex	HS Po	500	217623
C49	0.01μF	10	Suflex	Po	500	N20247
C50	150	2	Suflex	HS Po	500	217427
C51	0.01μF	10	Suflex	Po	500	N20247
C52	33	10	Suflex	HS Po	500	217610
C53	220	10	Suflex	HS Po	500	217615
C54	33	10	Suflex	HS Po	500	217610
C55	100μF		T. C. C.	CE59AE El	6	N20194
C56	Not fitted					
C57	0.1μF	25	Hunt	B512 M. Pa	350	206703
C58	0.1μF	25	Hunt	B506 M. Pa	250	206602
C59	Not fitted					
C60	2μF	25	Hunt	B503 MP	150	206505
C61	0.1μF	25	Hunt	B503 MP	150	206501
C62	0.0022μF	10	Suflex	HS Po	500	217621
C63	0.1μF	25			350	206703
C64	0.1μF	25	Hunt	B503 MP	150	206501
C65	0.1μF	25	Hunt	B503 MP	150	206501
C72	0.01μF	10	Suflex	Po	500	N20247
C73	0.0047μF	10	Suflex	HS Po	500	217623
C74	100	10	Suflex	HS Po	500	217613
C75	560	2	Suflex	HS Po	500	217434
C76	0.001μF	10	Suflex	HS Po	500	217619
C77	0.01μF	10	Suflex	Po	500	N20247
C78	3-30		Mullard	E7876 Var.	75	240002
C79	3-30		Mullard	E7876 Var.	75	240002
C80	0.001μF	10	Suflex	HS Po	500	217619
C81	1μF	25	Hunt	B503 MP	150	206504
C82	10	10	Suflex	HS Po	500	217607
C83	68	2	Suflex	HS Po	500	217423
C90	560	2	Suflex	HS Po	500	217434
C91	0.0015μF	2	Suflex	HS Po	500	217439
C92	150	2	Suflex	HS Po	500	217427
C93	0.01μF	20	T. C. C.	CP55GO Pa	2500	N20159
C94	0.01μF	10	Suflex	Po	500	N20247

Circuit Ref.	Value pF	Tolerance %	Manufacturer & Type		Rating Volts	Solartron Part No.
C95	0.1μF	20	T.C.C.	CP56X Pa	2000	N20249
C96	270	2	Suflex	HS Po	500	217430
C100	0.25μF	25	Hunt	B513 MP	350	206704
C101	1μF	25	Hunt	B503 MP	150	206504

Circuit Ref.	Type	Description	Manufacturer	Solartron Part No.	Interservice Ref. No.
V 1	12AX7	Triode Double	S.T.C.	315805	CV492
V 2	12AT7	Triode Double	S.T.C.	315801	CV455
V 3	6AM6	Pentode	S.T.C.	313203	CV138
V 4	12AT7	Triode Double	S.T.C.	315801	CV455
V 5	12AT7	Triode Double	S.T.C.	315801	CV455
V10	12AX7	Triode Double	S.T.C.	315805	CV492
V11	12AT7	Triode Double	S.T.C.	315801	CV455
V12	6AM6	Pentode	S.T.C.	313203	CV138
V13	12AT7	Triode Double	S.T.C.	315801	CV455
V14	EF86	Pentode	Mullard		CV2901
V15	12AX7	Triode Double	S.T.C.	315805	CV492
V20	12AX7	Triode Double	S.T.C.	315805	CV492
V21	12AT7	Triode Double	S.T.C.	315801	CV455
V22	6AM6	Pentode	S.T.C.	313203	CV138
V23	12AT7	Triode Double	S.T.C.	315801	CV455
V24	12AT7	Triode Double	S.T.C.	315801	CV455
V25	EF86	Pentode	Mullard		CV2901
V26	12AX7	Triode Double	S.T.C.	315805	CV492
V30	6AL5	Diode Double	S.T.C.	311651	CV140
V31	12AX7	Triode Double	S.T.C.	315805	CV492
V32	12AT7	Triode Double	S.T.C.	315801	CV455
V33	6AM6	Pentode	S.T.C.	313203	CV138
V34	12AT7	Triode Double	S.T.C.	315801	CV455
V40	6AM6	Pentode	S.T.C.	313203	CV138
V41	12AT7	Triode Double	S.T.C.	315801	CV455
V42	12AT7	Triode Double	S.T.C.	315801	CV455
V43	85A2	Reference	Mullard	313801	CV449
V44	R12	Rectifier H.W.	S.T.C.		CV426
V50	CVRX340	Multiplier Tube	G.E.C.		
V51	12AX7	Triode Double	S.T.C.	315801	CV492

MISCELLANEOUS

Circuit Ref.	Type	Description	Manufacturer	Solartron Part No.
SK 1	L1317	Socket 3 mm. Red	Belling & Lee	
SK 2	L1317	Socket 3 mm. Black	Belling & Lee	
SK 3	L604/S	Socket Coaxial	Belling & Lee	
SK 4	L1317	Socket 3 mm. Black	Belling & Lee	
SK 5	L1317	Socket 3 mm. Yellow	Belling & Lee	
SK 6	L604/S	Socket Coaxial	Belling & Lee	
SK 7	L1317	Socket 3 mm. Blue	Belling & Lee	
SK 8	L604/S	Socket Coaxial	Belling & Lee	
SK 9	RS16	Socket Unitor 16-way	McMurdo	
SK10	RS16	Socket Unitor 16-way	McMurdo	
SK11	RS16	Socket Unitor 16-way	McMurdo	
SK12	RS16	Socket Unitor 16-way	McMurdo	
SK13	RS8	Socket Unitor 8-way	McMurdo	
SK14	L1317	Socket 3 mm. Black	Belling & Lee	
SK15	L1317	Socket 3 mm. Black	Belling & Lee	
SK16	L1317	Socket 3 mm. Black	Belling & Lee	
SK17	L1317	Socket 3 mm. Black	Belling & Lee	
PL 6	RP8	Plug Unitor 8-way	McMurdo	
PL 7	CZ48995	Plug 6-way Mk. 4	Plessey	

Circuit Ref.	Type	Description	Manufacturer	Solartron Part No.
PL 9	RP16	Plug Unitor 16-way	McMurdo	
PL10	RP16	Plug Unitor 16-way	McMurdo	
PL11	RP16	Plug Unitor 16-way	McMurdo	
PL12	RP16	Plug Unitor 16-way	McMurdo	
PL13	RP8	Plug Unitor 8-way	McMurdo	
RLA	N29837 B3	Relay	Ericsson	
RLB	N298347 B3	Relay	Ericsson	
T1		Transformer		295037
T2		Transformer E.H.T.		
MSP		Mains Selector Panel		279001
L1		Coil assembly		
FS1	L1055/3	Fuse 3A	Belling & Lee	372275
LP1	SL80	Lamp (less resistor)	Arcolectric	
LP2		Lamp M.E.S. 11 mm.		374359

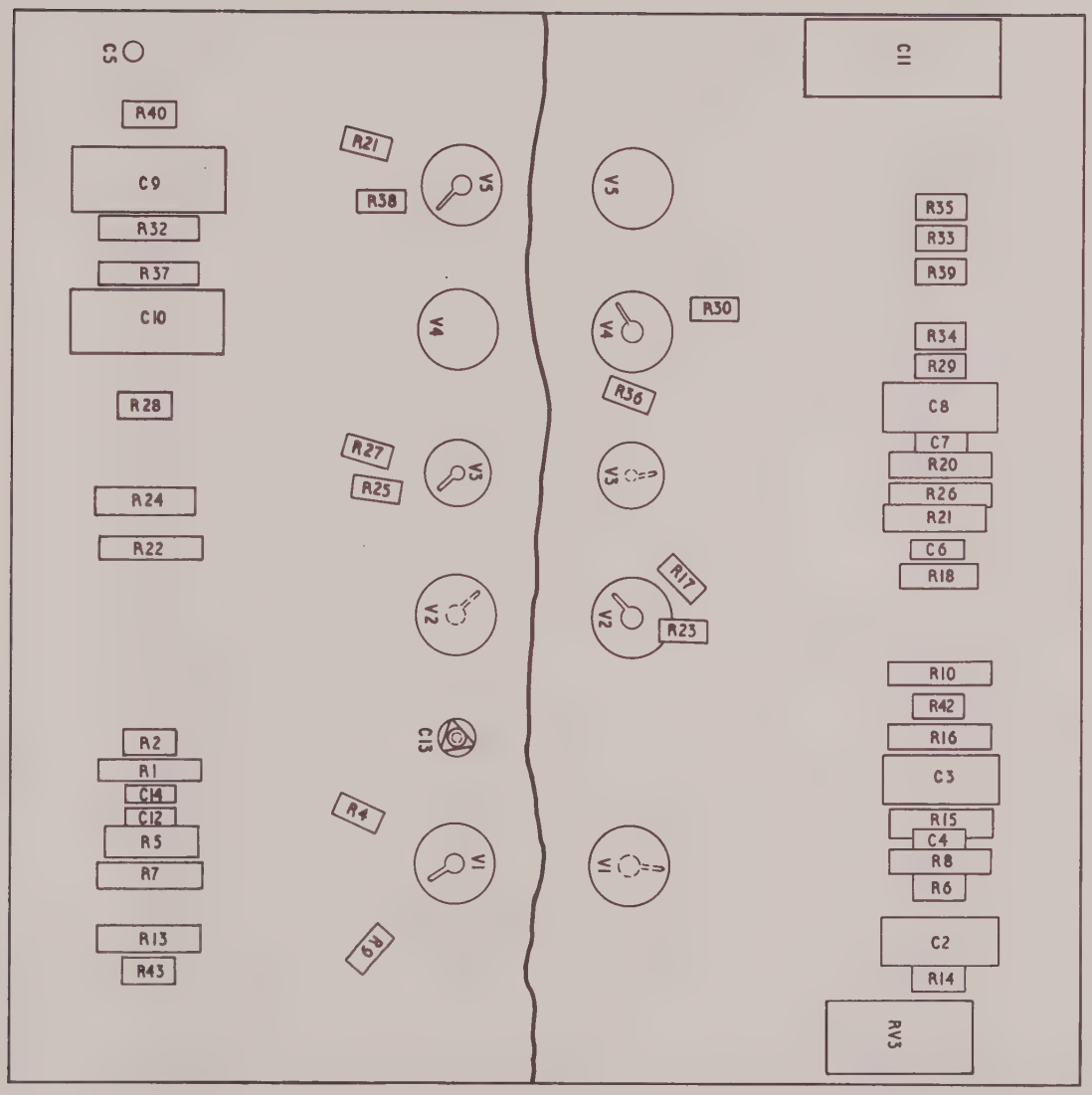

Fig. 15. Coil Amplifier Component Layout

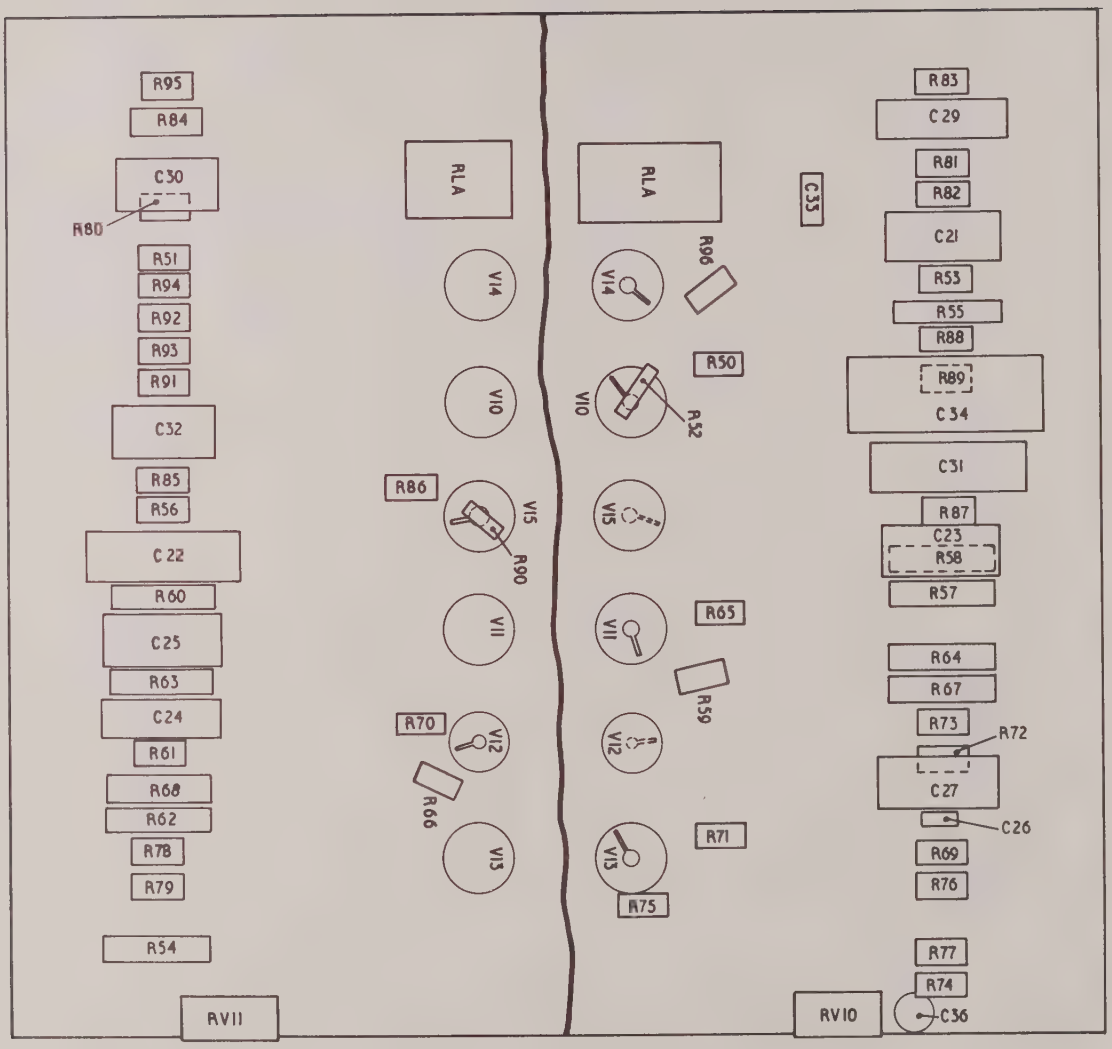

Fig. 16. Current Inverter Component Layout

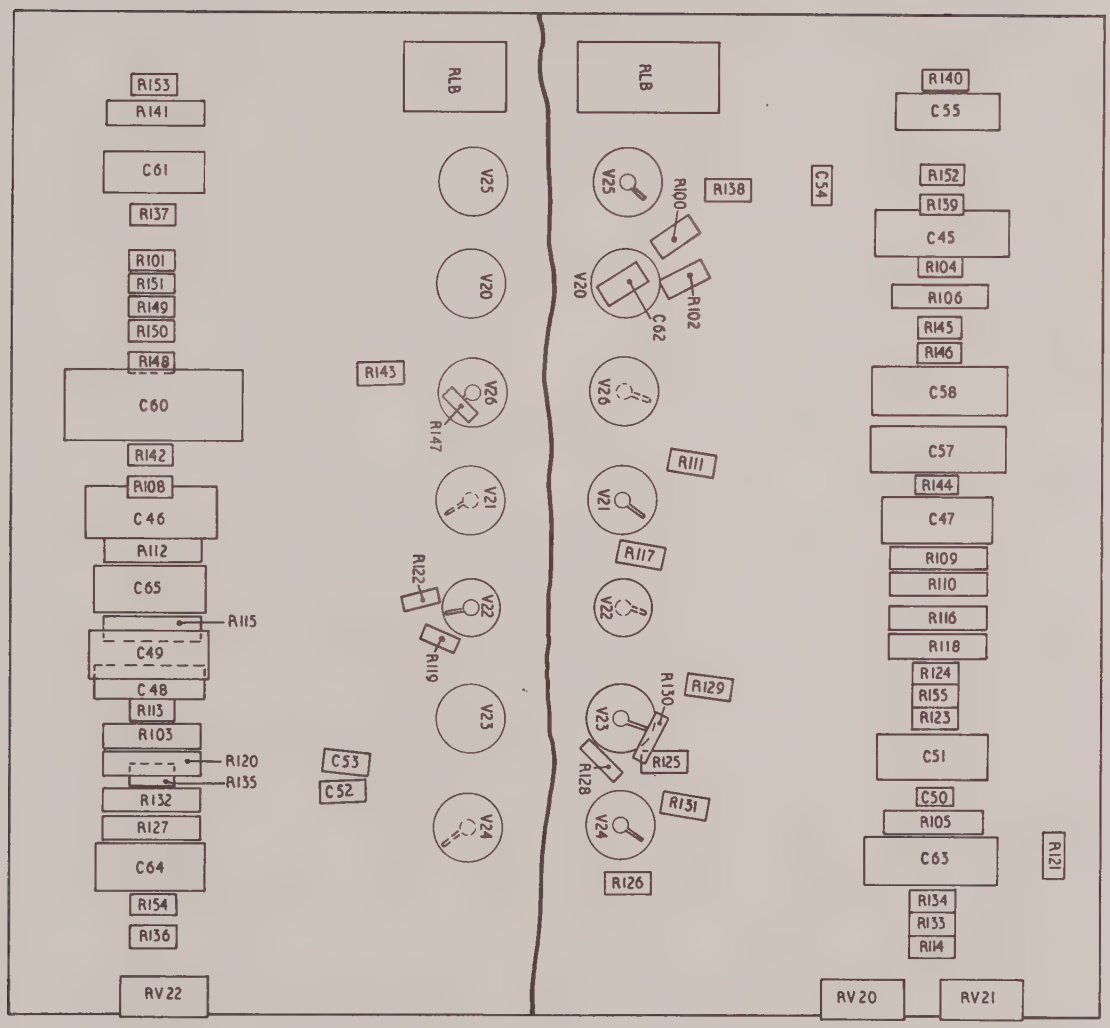

Fig. 17. Servo Amplifier Component Layout

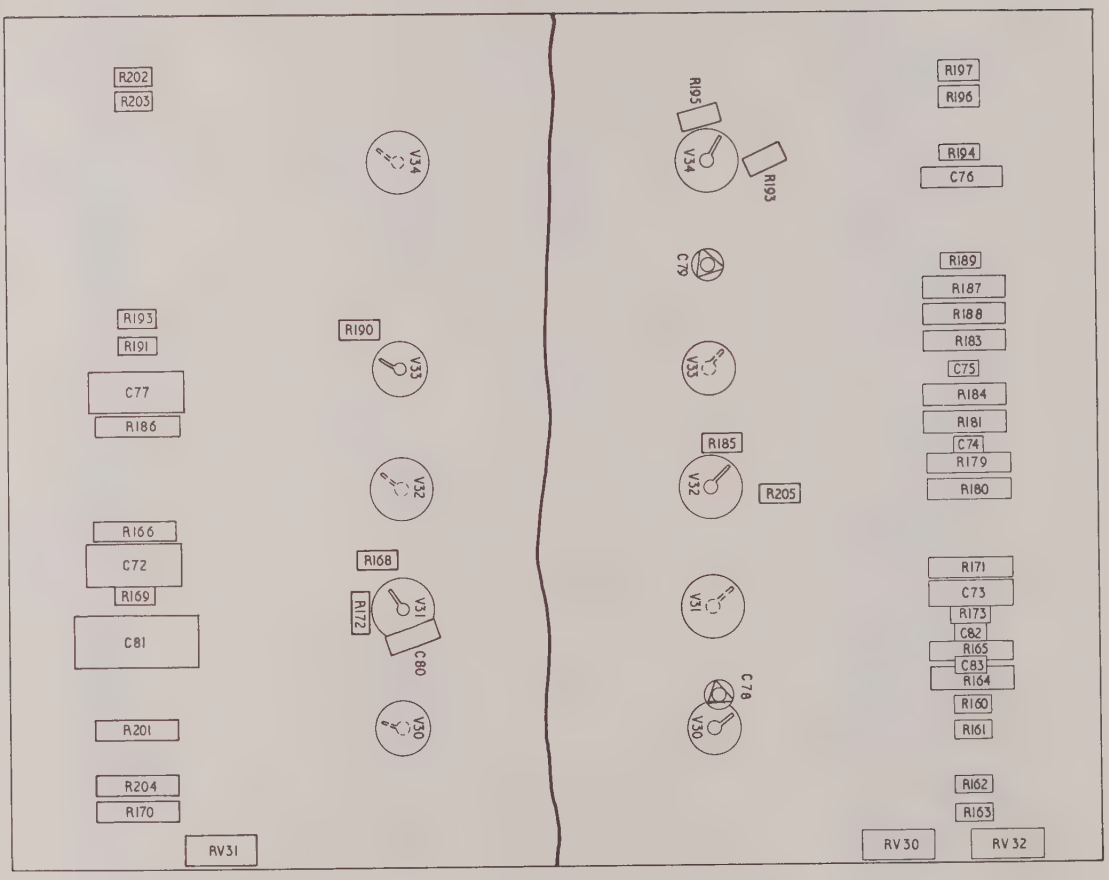

Fig. 18. 'X' Amplifier Component Layout

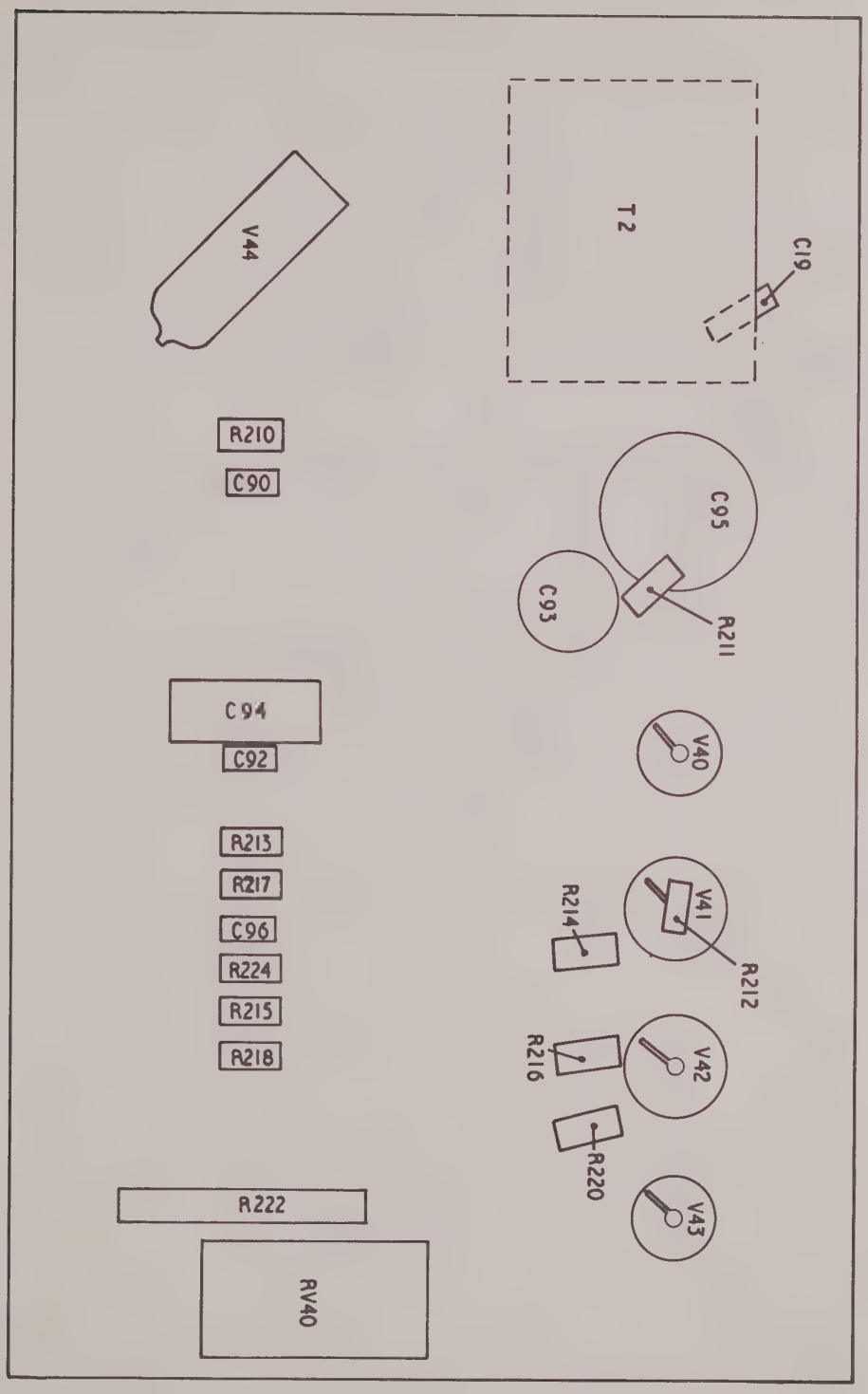

Fig. 19. E. H. T. Unit Component Layout

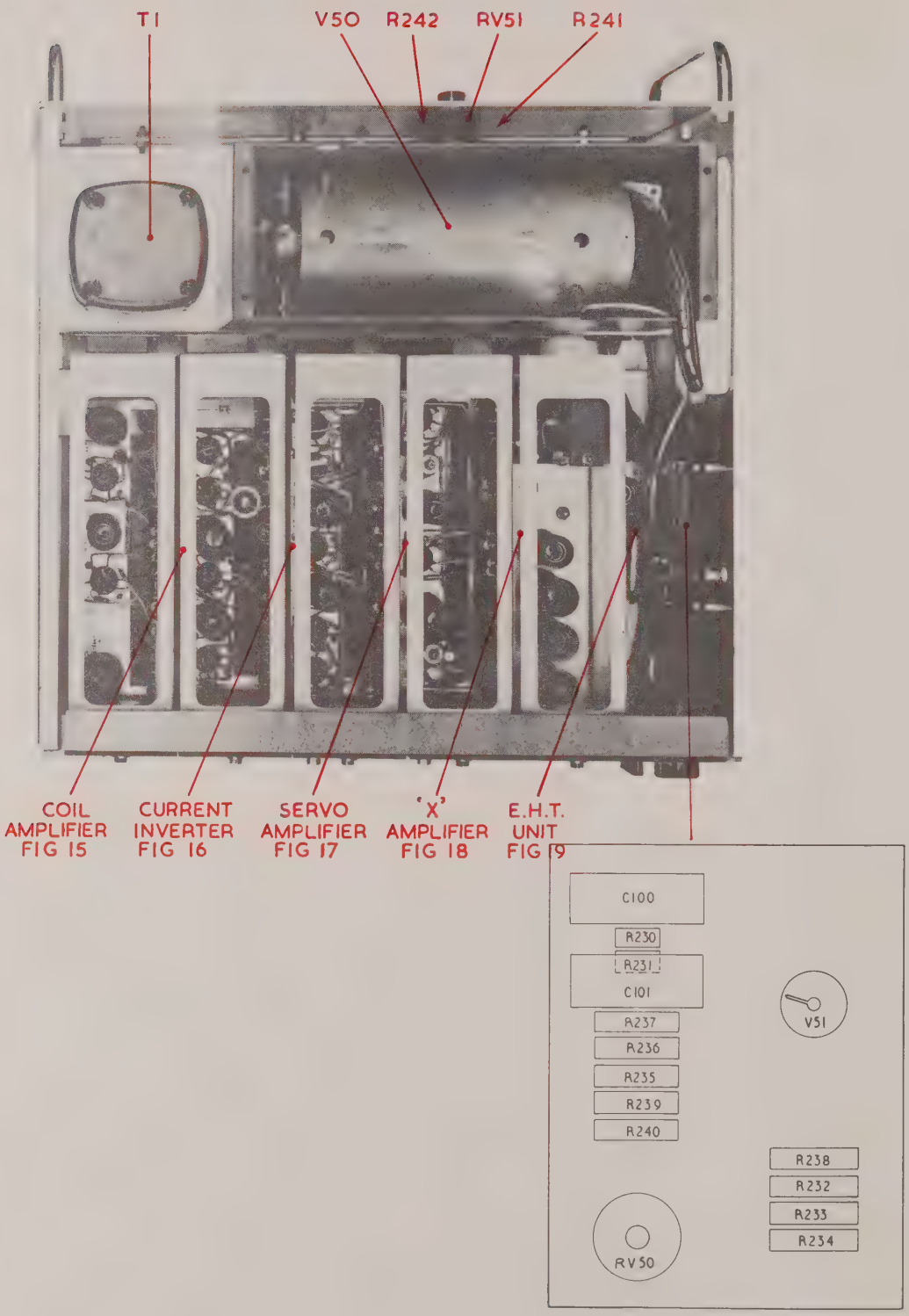

Fig. 20. Main Frame Component Layout

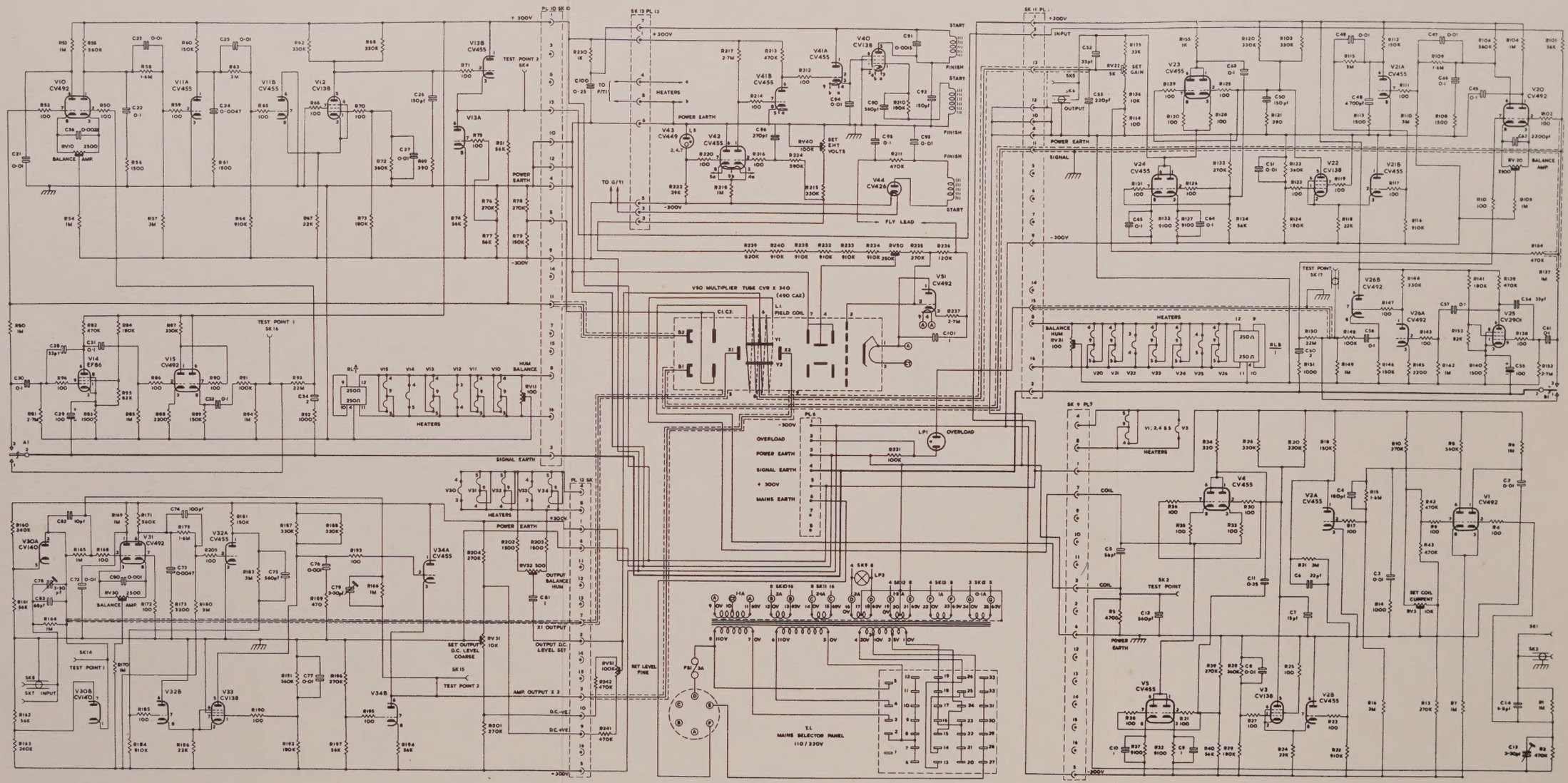

Fig. 21. The Crossed Fields Multiplier. Complete Circuit.

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